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COUNTRY RISK AND THE INTERNATIONAL FLOWS OF TECHNOLOGY: EVIDENCE FROM THE CHEMICAL INDUSTRY[♣]

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Abstract

We empirically investigate the relationship between country risk and the international flows of technology. Using a comprehensive database on investments in chemical plants during the period 1981-1991, we show that higher levels of country risk are associated with fewer technology transfers to recipient economies. This holds true both for wholly owned operations and for more market-based transactions. The analysis also suggests that technology transfers with smaller resource commitment tend to be preferred in country with higher levels of risk. Hence, higher country risk not only does it reduce the amount of wholly owned investment, it also contributes to shift from this type of technology transfer to more market-mediated means, such as licensing. After controlling for several country characteristics, we do not find intellectual property rights protection playing a significant role in fostering technology transfers or conditioning the transfer mode.

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Introduction

The past decade has been marked by the increasing importance of international technology flows. The 1999 World Investment Report shows that the worldwide flow of foreign direct investment has passed $600 billion in 1998. Arora, Fosfuri and Gambardella (2001) have stressed the increased importance of market-based transactions for technology in the last two decades of the XX century. Cross-border alliances and joint ventures have become widespread in the last few years.

As the need to exploit technological assets on a global scale becomes more and more imperative, companies as well as governments seeking to attract international technology must have a good understanding of trends in technology flows. In this paper we shall focus on one important, and yet not very well studied, factor affecting international technology flows, namely country risk. During the 90s some countries have experienced important differences in their idiosyncratic risk. Countries like Yugoslavia and Iraq have more than doubled their level of risk. Similarly, countries like Indonesia, Cameroon, Pakistan and Algeria have experimented very significant increases. On the other side, Poland, El Salvador, Peru, Costa Rica and Panama have more than halved their level of country risk.[1]

Firms, and managers in particular, seem to put a lot of attention on the changes of investment conditions in different countries. Anecdotal facts suggest that rises in country-specific risk have an immediate effect on international investment which is often considered footloose and ready to move to safer places. The proliferation of country ratings, which should serve as an aid to decision-making in the assessment of country risks, provides other evidence of the close relationship between international investment and country-specific risk.

The purpose of this paper is to offer a closer look at the impact of country risk on the inflow of international technology. We distinguish between three modes of international technology transfer: wholly owned operations, joint-ventures and licensing. We account for the simultaneity of the technology transfer decision. In addition, we estimate the relative effect of country risk on wholly owned operations, licensing and joint-ventures.

Our results suggest that the net effect of an increase of country risk is a reduction of the flow of technology into the recipient country. We also find that changes in country risk affect the composition (not only the volume) of international technology transfer since firms tend to respond to higher levels of risk by adopting modes of technology transfers, such as licensing, which involve less resource commitment.

Finally, we also contribute to the huge debate on the importance of policies aimed at stricter enforcement of intellectual property rights (IPRs). Advocates of these policies argue that stronger IPRs protection would enhance technology flows and foreign downstream investment in the recipient countries, that, via spillovers, could favor the technological catch-up of less developed countries. Unfortunately, our results suggest that, at least for the chemical industry, international technology flows do not seem to be sensitive to the protection of IPRs. Moreover, contrary to what has been purported by the theoretical literature, stronger IPRs do not even affect the composition of international technology flows.

1. Related Literature, Contribution and Limitations

The main contribution of this paper is to underscore the relationship between country-specific risk and the international flows of technology. There is an empirical literature focussed on country risk as an explanatory factor for the amount of foreign direct investment in a given country. However, little is known about other means through which technology is typically transferred internationally, namely joint-ventures and licensing. In addition, we shall account for the simultaneous effects of country risk on wholly owned operations, joint-ventures and licensing, and we shall provide empirical results on the relative effects as well.

One of the first studies which has focused on the relationship between risk and foreign direct investment is Flamm (1984). He estimates an equation relating multinational electronics investments to relative wages, using country-specific dummy variables as proxies for differential

[1] These figures are obtained by comparing the Institutional Investor credit ratings (IICR) of the different countries at the beginning of the year 1990 and at the end of 1999. See later for details on the IICR.

risk. His results seem to suggest that firms are very much concerned with having a balanced risky portfolio so they respond quickly to changes in country risk.

Wheeler and Mody (1991) also investigate the impact of country-specific risk on foreign direct investment. They measure risk as a first principal component extracted from a set of indices which measure political stability, inequality, corruption, red tape, quality of the legal system, cultural compatibility, attitude toward foreign capital and general expatriate comfort. They find that firms seem to assign little importance to perceived risk, except for some modest weight attached to geopolitical considerations.

A bunch of studies on foreign direct investment in emerging markets has put particular stress on indicators of economic and political risk (Lucas, 1993; Jun and Singh, 1996; Holland and Pain, 1998). A recent paper by Bevan and Estrin (2000) using a panel data set containing information on foreign direct investment flows from 18 market economies to 11 transition economies over the period 1994-1998 finds that foreign direct investment inflows are strongly influenced by country risk, among other factors.

Our paper shows that the whole flow of technology transfer into a recipient economy is negative related to the level of country risk. Moreover, this effect holds for all technology transfer modes considered in our analysis, namely wholly owned operations, joint-ventures and licensing. Finally, we are also able to show that the relative effect is stronger for technology transfer modes which involve greater commitment with the recipient country, such as wholly owned operations. In sum, higher levels of country risk mean less technology transfer, that tends to be more market-based.

This paper also contributes to the growing literature on international technology transfers and IPRs protection. Several papers have focussed on the link between IPRs and trade. (Among others, see for instance Maskus and Penubarti, 1995, and Smith, 1999.)

nship between IPRs and foreign direct investment. The results have been mixed. For instance, Mansfield and Lee (1996), using a survey index for sixteen developing and newly industrialized countries, report a positive and significant impact of IPRs on foreign direct investment flows. However, Fink (1997), using US foreign direct investment in 42 countries in a gravity-type model, shows that, if at all, the link between IPRs and multinational activity is negative. Few studies have addressed the link between other means of technology transfers and IPRs. A notable exception is Fink (1997) which reports a weak positive relationship between IPRs and licensing activity. Finally, Ferrantino (1993), Maskus (1998) and Smith (2001) provide the only previous empirical studies that link IPRs with simultaneous decisions about servicing. Smith (2001) shows that IPRs have a positive and significant effect both on foreign direct investment and licensing, but no effect on exports. The effect is more pronounced for licensing and tends to be stronger in countries with strong imitative abilities, supporting the idea of IPRs generating a market expansion effect.[2]

In our paper we cannot find any significant relationship between the strength of IPRs protection and the flows of technology transfer, whatever is the mode chosen by the investor. In addition, we do not find any indication of market expansion effect or market power effect due to stronger IPRs. Since the chemical industry is a prototypical example of R&D-based industry, our results seem to confirm Maskus and Penubarti (1995)'s finding that the most patent-sensitive industries are, on average, unaffected by the scope of protection.[3]

One virtue of our paper vis-à-vis the rest of the related literature is that we have very detailed plant level information. This allows us to study firms' decisions concerning the preferred mode of technology transfer and show how and if our explanatory variables affect firms' choices. However, two important limitations should be put upfront: first, we do not have exports figures,

[2] Smith (2001) distinguishes between a "market expansion effect" and a "market power effect" due to stricter enforcement of IPRs. The former holds that strong IPRs expand foreign markets available for servicing by ensuring exclusive rights over knowledge that flows to the foreign country. The latter holds that strong IPRs reduce investment by ensuring a temporary monopoly over the protected knowledge. See also discussion in section 3.

[3] According to Cohen, Nelson and Walsh (2000) patents are considered by firms as one of the less effective means to protect their intellectual property. This is especially true for process innovations, the ones we consider in the paper.

so our analysis is limited to technology transfer modes which imply the transfer of production in the recipient country; second, we have data of only one industry, so that the extent to which our results can be exported to other industries remains unclear.

2. Theoretical Background

Most of the theoretical work on international technology transfer has been spurred by Dunning's "eclectic paradigm" (Dunning, 1981). Such a paradigm suggests that firms locate production abroad when there are "location" advantages in doing so. These advantages might be due to trade barriers, cheap factors of production, transport costs and the like (see among others, Motta, 1992). However, "location" advantages do not need foreign direct investment to materialize. Arm's length arrangements such as licensing might work as well. The choice between the two depends of what Dunning labels "internalization advantages". Applying the insights of the transaction cost theory (Williamson, 1991), this approach suggests that, absent significant contracting hazards, the 'default' low-cost governance mechanism is a simple contract. However, writing and executing a reliable contract for the use of technology requires adequate specification of property rights, monitoring and enforcement of contractual terms – any of which may be problematic.

In Ethier (1986), Horstmann and Markusen (1996) and Wright (1993) the presence of asymmetric information between the technology holder and the potential licensee generates costs which could be avoided through a wholly owned subsidiary. In Ethier and Markusen (1996) and Fosfuri (2000) the threat of imitation might induce the investor to internalize production and, in some cases, to resort to exports.

There are basically no formal models which explicitly incorporate risk. In Wheeler and Mody (1991) the expected profits of undertaking a foreign direct investment are negative related to the level of country risk so that higher risk implies less investment. Baven and Estrin (2000) develop a simple model where again risk affects negatively expected profits of multinational investment.

So, in light of their findings, the fact that changes in patent protection do not affect international technology flows

The relationship between risk and investment is straightforward. Other things being equal, higher risk reduces the expected profits from the investment and hence the propensity to invest. So, one should expect a reduction in the expected profits of any of the three forms of international technology transfer analyzed here. This is straightforward in the case of wholly owned operations, where the investor is the residual claimant of all possible profits, and in the case of joint-ventures, where the investor typically receives a share of the whole profits, but it is also true for licensing, where royalties and other types of payments tend to be, although spuriously, related to the expected profits obtainable through the exploitation of the technology.

If one assumes that the outside best option for the investor (it could be not investing at all or exporting) is independent of (or less respondent to) changes in country risk, then the following proposition follows immediately:

> **Proposition 1**: *The flows of technology transfer into a given country is negatively related to the level of country risk.*

Notice that this does not imply the all three forms of technology transfer (wholly owned operations, joint-ventures, and licensing) increase when the level of country risk decreases. Indeed, the three modes involve a very different level of resource commitment. By resource commitment we mean dedicated assets that cannot be redeployed to alternative uses without cost (loss of value). These assets may be tangible (e.g. physical plant) or intangible (e.g. management know-how). In the case of licensing, the licensee bears most of the costs of opening up and serving the foreign market. In the case of a wholly owned operation, the investor has to bear all the costs. The level of resource commitment consistent with a joint venture will fall somewhere between these two extremes.

Where country risk is high, the investor might be well advised to limit its exposure to it by reducing its resource commitments and increasing its ability to exit from the market quickly without taking a substantial loss should the environment worsen. This in itself suggests that, other things being equal, licensing and joint-ventures will be favored over wholly owned operations when country risk is high.

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does not appear to be too surprising.

This implies that higher country risk has a clear negative effect on the flow of wholly owned operations. The effect on joint-ventures and licensing is less straightforward. For instance, consider licensing. From the one hand, we have argued above that the expected profits from licensing tend to reduce with risk, so do the incentives to employ this mode of technology transfer. On the other hand, higher risk might force international investors to opt for modes with reduced resource commitment. This might increase the flow of licensed technology. The net result is ambiguous and licensing flows theoretically might either increase or decrease with country risk. What is unambiguous is that the coefficient of country risk on licensing flows must be smaller than the coefficient of country risk on flows of wholly owned operations. A similar argument could be put forward for joint-ventures.

Proposition 2: *The impact of a reduction in country risk on the flow of wholly owned operations is larger than the impact on the flow of joint-ventures that, in turn, is larger than the impact on the flow of technology licensing.*

3. Model Specification and Data

4.1. Specification

We assume that technology transfer flows are a function of a set of country variables which could account for the demand of technology in a given country (D_i), of country risk (R_i) and of some distortion parameters (P_i):

$$TF_i=f(D_i, R_i, P_i), \tag{1}$$

where i is the country subscript.

Among the country variables we shall include income per capita, population and distance. These three variables are intended to capture respectively for relative endowments, market size and transportation costs. Markusen (1995) provides a survey of models that generate these core explanatory variables, which are consistent with the so called gravity model. These variables are also used in Smith (2001), Brainard (1997) and Primo Braga and Fink (1998) among others. In addition, we introduce a measure of the country level of education. This measure is intended to control both for the ‘absorptive capacity’ of the country and for the imitative abilities of the domestic firms.

Finally as distortion parameters, we have considered the country openness to trade and the degree of protection of IPRs.[4]

We apply the following specification:

$$TF_{ijt} = \beta_0 POP_{it}^{\beta_1} PCGDP_{it}^{\beta_2} DIST_i^{\beta_3} R_{it}^{\beta_4} IPR_{it}^{\beta_5} OPEN_{it}^{\beta_6} HUMAN_{it}^{\beta_7} \varepsilon_{ijt} \tag{2}$$

where the subscript i denotes the country, the subscript t denotes the time period, and the subscript j denotes the mode of technology transfers (wholly owned, joint-venture or licensing). POP is the population of the country, PCGDP is the per capita income, DIST is the weighted distance to capitals of world 20 major exporters, R is country risk, IPR is the degree of patent protection, OPEN is openness to trade, HUMAN is a measure of the country level of education, and ε_{ijt} is a log normally distributed error term. T_{ijt} takes the form of separate (not summed) wholly owned operations, joint-ventures and licensing.

Taking natural logs of equation (2) one obtains the following:

$$\begin{aligned} \ln(TF_{ijt}) &= \beta_0 + \beta_1 \ln(POP_{it}) + \beta_2 \ln(PCGDP_{it}) + \beta_3 \ln(DIST_i) + \ln(R_{it}) \\ &+ \beta_5 \ln(IPR_{it}) + \beta_6 (OPEN_{it}) + \beta_7 \ln(HUMAN_{it}) + \varepsilon_{ijt} \end{aligned} \tag{3}$$

Notice that we do not take the log of OPEN because this variable is a share.[5]

Figure 1 summarizes the predicted parameter signs for each form of technology transfer. First, we expect a positive parameters on PCGDP and POP in all equations. The theoretical literature lacks consensus on whether transportation costs (DIST) and trade barriers (OPEN) increase or decrease technology transfer flows. For example, models of substitution behavior predict that firms establish affiliates or licenses as a way of skirting barriers to export (the so-called “tariff-jumping

[4] We have experimented with several other variables, like barriers to trade of capital goods, participation to free trade agreements, tax rates, level of infrastructure, dummies for geographical areas, etc. Most of them showed an insignificant coefficient and the inclusion or exclusion did not affect the results reported here. For brevity, we do not report these results, which are available upon request from the author.

[5] Both IPR and R are indexes which vary on a scale from 0 to 5 (with 5 meaning the highest level of IPRs protection) and from 0 to 100 (with 100 meaning the lowest level of country risk) respectively. For IPR we have used log(1+IPR). Since for R the minimum value is 4.4 we have simply taken the log.

argument"; see Motta, 1992). However, models of complement behavior predict that conditions which decrease (increase) exports also decrease (increase) technology transfer modes which involve location in the foreign country (Smith, 2001). We have already said that country risk has a positive impact of wholly owned operations in the recipient economy (in the sense that less risk - larger values of R - increases the amount of investments). However, the effect on joint-ventures and especially on licensing remain ambiguous. As far as it concerns IPRs the effect of changes in the strength of protection on any form of technology transfer considered here is far from being clear-cut (Maskus and Penubarti, 1995; Primo-Braga and Fink, 1998; Smith, 2001). From the one hand, stronger IPRs enhance the ownership advantage of the source firm in the foreign market by providing legal recourse against violations of its assets. This is likely to reduce imitation by foreign firms and thus making more appealing the technology transfer activity. This is known as the "market expansion effect". On the other hand, stronger IPRs also confer to the foreign firm more market power, which can be exploited by reducing the supply of products, by rising the price, and restricting the investment in the recipient country. This is known as the "market power effect". Finally, the sign of HUMAN is also ambiguous. The level of education might capture the "absorptive capacity" of the recipient country (Cohen and Levinthal, 1989). In this case, better educated workers available in the host country would facilitate both the creation of a wholly owned activity, the establishment of a joint-venture with a local partner and the transmission of technological knowledge to any potential licensee. However, higher level of education – better technological skills – might imply that local firms are better equipped for quickly imitating the technology of the foreign company. This means that the investor will try to protect its technology, reduce if possible any technological leakage, and ultimately restrict the amount of investment and technology transfer to the recipient country (Fosfuri, 2000; Fosfuri, Motta and Roende, 2001).

FIGURE 1 ABOUT HERE

4.2. Data

Data on international technology flows are obtained from Chemical Age Project File (CAPF), a large commercial database on worldwide investments in chemical plants during the period 1981-

1991. For each chemical plant, the database reports both the name of the operating company and the name of the licensor when the technology used in the plant is bought from an unaffiliated source. In addition, it identifies when the property of a given plant is shared among different firms.[6] In other words, using our database it is possible to trace back the entire set of wholly-owned and joint-venture plants in foreign countries and the whole flow of international technology licensing in the chemical industry during the period under study. The database also provides information about plant investment costs.

In order to identify the plants belonging to each technology transfer mode, we have constructed a sample of large chemical firms. Such firms, given their large financial, managerial and organizational capabilities, were likely to have the option to decide the preferred mode of technology transfer in any recipient country. Small chemical firms and, in particular, specialized engineering firms (SEFs)[7], which are also quite active in international technology licensing, have to restrict their strategy space to whether they want to license or not. Since we would like to consider a framework where the mode of technology transfer is a decision variable for the investor (i.e. the foreign firm endowed with the technology), our sample is better suited for the type of analysis we are going to perform.

Our sample includes all chemical firms from developed countries (Western Europe, USA and Canada, and Japan) which had, by the year 1988, more than $1 billion in aggregate sales (the list of firms is obtained from Aftalion, 1989). Of this set of firms only 142 had at least one international technology transfer scored in CAPF in the period under study. These are the firms we use in our study. By nationality, we have 64 US firms, 1 Canadian firm, 28 Japanese and 49

[6] Although the database shows the names of different firms when the plant is co-owned, it does not systematically report the distributions of shares among co-owners. In addition, we believe that co-ownership of plants is underreported in the database. For instance, cases of minority participation are not reported. Notice also that other studies refer to foreign direct investment as any participation larger than 10%. Under this definition, it is likely that all wholly owned and joint-venture plants in our database would belong to the foreign direct investment category. We have estimated a model with only two technology transfer modes, foreign direct investment and licensing. Results do not change significantly.

[7] SEFs are firms specialized in the design, engineering and construction of chemical plants, with no roots in manufacturing. SEFs originated as an American phenomenon and some of them were founded very early after the war or even in the 1920s. Although their expertise is on the design and engineering of chemical plants, they are also very active in the licensing market. With some prominent exceptions such as UOP and Halcon/Scientific Design,

European firms. We think that overall the sample includes companies which have the option (i.e. financial and managerial capabilities) to switch from one entry mode to another depending on country characteristics. Table 1 shows the list of the most active firms in technology transfer during the period under study.

TABLE 1 ABOUR HERE

The sample is representative of the population of international technology transfers in the chemical industry. Firms of our sample cover close to 60% of all foreign direct investments in the period (either wholly owned or joint-venture) and more than one third of international licensing agreements. A big chunk of international licensing is undertaken by SEFs (about two fifths). As we discussed in footnote 7, these are firms focussed on the design, engineering and construction of chemical plants with no downstream production facilities. The only option to profit from their innovations is through licensing.

Table 2 shows the distribution of technology transfers by the firms of our sample across geographical areas during the period 1981-1991.[8] The table reports both the number of transactions and the total value of investment generated by such transactions.

Notice that licensing is the predominant mode of technology transfer in most third world areas (the only exception is South America). On the contrary, licensing accounts for less than 20% in most developed areas. Here, the exception is Japan where more than 40% of the inflow of technology is through licensing. As a remark to this table it is worthwhile noting that the popular wisdom on IPRs holds that countries where protection is the strongest tend to have the largest share of technology transferred through market-mediated mechanisms such as licensing. However, our data seem to suggest that developed countries which have typically the best protection of intellectual property tend to show foreign direct investment as the predominant mode of technology transfer. Other factors should be therefore accounted for this empirical finding. Country risk might be one of such factor. Licensing implies a smaller investment and

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SEFs do not focus on breakthrough innovation. However, they improve and modify processes developed by chemical firms and offer those for licensing. See Arora and Gambardella (1998) and Arora and Fosfuri (2000).

[8] We have also looked at the technology transfer pattern of firms with different nationality. US and European firms (globally taken) tend to behave similarly with about 25% of licensing activity. Japanese firms have a stronger attitude towards licensing which accounts for 60% of their international technology transfer activity.

thus it is better suited for countries where the risk is high (i.e. Eastern Europe, Middle East, Africa).[9]

TABLE 2 ABOUT HERE

Finally, there is also some variation across sectors according to the predominant mode of technology transfer. For instance, sectors like Plastics and Industrial Gases show licensing as the most used mode of technology transfer. On the other extreme, in Pharmaceutics and Organic Chemicals wholly owned operations account for more than 90% and 75% respectively. See Table 3. This suggests that there might be factors related to the technology which could be lost at a country-level aggregation. Some technology might be more standardized, easier to transfer through contracts (Kogut and Zander, 1993) or there might exist more competition in the licensing market (see Arora and Fosfuri, 2002). All these factors favor a more extensive use of licensing as a mode of international technology transfer.

TABLE 3 ABOUT HERE

We aggregated our data on technology flows in three time periods: 1981-1983, 1984-1987, 1988-1991. Hence, we shall use the subindex $t=1,2,3$ for each of the three periods respectively. There are three reasons for such aggregation. First, some country variables tend to change slowly so that they do not basically show variability from one year to another. Second, from the decision to pursue a technology transfer and the actual investment it typically takes several months or years. So, technology transfer decisions tend to be more correlated to long run changes rather than short run changes in country conditions. Third, in many countries (especially, the smaller ones) and for many years the flows of technology transfers would be zero. In addition, such aggregation would make us much more confident on the reliability of the information about the year of construction or expected construction of the plant that CAPF reports. We have also run our estimations pooling all data in a single cross-section. Results do not change and such regressions are available upon request from the author.

All our explanatory variables that have time variability have been measured at the beginning of each time period. The only exception is our measure of IPRs which was only available for the

[9] Restrictions to foreign capital might also play an important role here.

year 1980, 1985 and 1990 (we have therefore assumed that these correspond respectively to our three periods).

We use a set of 71 countries for which we could collect comparable data on the characteristics described above. The list of countries is reported in the appendix. We have therefore a panel of 213 observations. Notice that the cross-time variability is quite modest for some country variables (like for instance IPRs). For others, like risk, is much more important.

For POP, PCGDP and OPEN we have used the Penn world tables (which are available on-line at http://datacentre2.chass.utoronto.ca/pwt/). DIST and HUMAN have been obtained from Barro-Lee (1994).[10]

We measure the strength of IPRs using an index developed by Ginarte and Park (1997). This index uses a coding scheme applied to national patent laws, where five categories are considered: extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms and duration of protection. One limitation of this measure is that it is based on statutory protection, which might actually differ from the real protection (whether patent laws are enforced or not). We have also experimented with the index developed by Rapp and Rozek (1990). This index is only available for the mid 80s and reflects the conformity of national patent laws with minimum standards proposed by the US Chamber of Commerce. Both indexes are highly correlated and using one instead of the other does not affect any of the results we shall show below.

As a proxy of country risk we used the institutional investor credit ratings. Institutional investor credit ratings are based on a survey of leading international bankers who are asked to rate each country on a scale from zero to 100 (where 100 represents maximum creditworthiness). Factors which are taken into consideration in this measure include the economic and political outlook, debt service, financial reserves, fiscal policy, access to capital market, trade balance and investments. Surprisingly, Erb, Harvey and Viskanta (1996) notice that such index has a higher correlation with a measure of political risk rather than a measure of financial risk both developed by the Political Risk Services' International Country Risk Guide (ICRG). In our estimation, to

[10] Available on-line at http://www.nuff.ox.ac.uk/Economics/Growth/barlee.htm.

assess the sensitivity of the results we also use a weighted average of the political, economic and financial risks developed by the ICRG. This measure is only available starting from the mid 80s. We find that our results are robust with respect to the choice of measure. The institutional investor credit ratings have been used by Baven and Estrin (2000) to assess the impact of country risk on foreign direct investment in a set of transition economies. Other papers, like Wheeler and Mody (1991), have used more complex measures of country risk. We favor an approach in which the country risk is proxied by information actually available to firms at the time of the investment decision – the credit rating – which can be purchased commercially.

Finally, we include DUM1 and DUM2, two dummy variables, which should control for time period fixed effects.

Table 4 summarizes our variables along with their source, whereas Table 5 provides some basic descriptive statistics.

TABLE 4 AND TABLE 5 ABOUT HERE

5. Empirical results

Table 6 (model 1) reports the OLS estimation of equation (3) where the dependent variable is the logarithm of the sum of the investment generated by any of the three modes of technology transfer (wholly owned operations, joint-ventures and licensing) in country *i* in period *t*. In other words, we are proxing the flows of technology transfer by the value of investment that technology transfer ultimately generates in the recipient economy. Using number of plants instead of dollar values gives very similar results.[11]

Results are as expected. Both POP and PCGDP have a positive and significant effect on the total flow of technology transfer. DIST is positive, suggesting that transportation costs favor location of production in distant countries, but barely significant. OPEN is positive and significant at the 10% level, meaning that more open countries tend to attract larger international flows of technology. IPR does not seem to play any role in conditioning the volume of technology transfer. HUMAN is also no significant at all.

The coefficient of R is positive and highly significant. This implies that increases in the country credit ratings, our proxy for country risk, generate a larger flow of technology transfer in the recipient economy. In dollar terms, this means that, in the average recipient country, a 10% increase in R with respect to the mean (about 46) generates an increment in the investment driven by international technology transfer of about $50 million a year.

We have also performed a Tobit estimation (model 1a) of equation (3). Indeed, about a third of the observations for our dependent variable shows no investment at all in a given country and for a given time period. A Tobit estimation should account for the truncated (at zero) dependent variable. Qualitative results hold unchanged.

TABLE 6 ABOUT HERE

[11] Regressions are available from the author upon request.

As we discussed in section 3, the fact the IPR has no effect on international technology transfer is not in contradiction with the theory. Indeed, stronger IPRs generate a market expansion effect and a market power effect. Since the former is positive and the latter is negative, the net effect is ambiguous. However, one can refine the theory a bit more. As suggested by Smith (2001), the risk of imitation is higher in countries with strong imitative abilities. Hence, one should expect that it is in these countries that the market expansion effect is stronger. Instead, in countries with poor imitative abilities an increase in IPRs protection would reinforce the market power of the investor and could possibly lead to a reduction in the flow of technology transfer.

In order to test this additional implication of the theory we divide all our countries in two groups: countries with strong imitative abilities and countries with weak imitative abilities. We use the median of HUMAN to separate the two groups. Then, we define two dummy variables: DWEAK, which takes the value of one if the country has weak imitative abilities and zero otherwise; DSTRONG, which takes the value of one if the country has strong imitative abilities and zero otherwise. Finally, we estimate an equation where these two dummies are multiplied by the variable IPR.[12] Results are reported in Table 6, Model 2 for OLS and Model 2a for Tobit. As one can check, we again do not find any evidence of a significant impact of changes in IPRs protection on the flow of technology transfer. However, this does not mean that individual modes of technology transfer are not affected by changes in IPRs protection. An increase in licensing could be leveled out by a similar decrease in wholly owned operations giving a no significant coefficient in Table 6. We shall explore this possibility below.

We can now analyze the impact of our main explanatory variables on any single form of technology transfer, taking into consideration the simultaneous character of the three modes. The empirical method is to estimate equation (3) for the three modes of technology transfer using seemingly unrelated regression (SUR) techniques. Table 7, model 3a, reports the results of the SUR estimations of equation (3).

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[12] As a sensitive test we have also used the number of R&D scientists and engineers per million of population to define weak and strong imitative abilities. Countries with a number lower than 500 were considered as poor imitators whereas countries with more than 500 where considered as good imitators. We found again no significance in the coefficients for IPRs protection.

Overall the results seem to confirm the theoretical predictions discussed in section 3. POP and PCGDP are positive and significant in all equations. DIST is positive, but significant only for the JV and LIC equations, whereas OPEN is only significant and positive in the WO equation. The latter finding might suggest that more open countries tend to attract larger flows of wholly owned operations. HUMAN is positive and significant at the 10% level in the WO equation and negative and significant in the LIC equation. Taking at its face value this implies that "absorptive capacity" plays a more important role in wholly owned operations, whereas the threat of imitation in countries with strong imitative abilities might reduce the inward flow of technology licensing. IPR does not have a significant effect in any of the three modes of technology transfer. R is positive and highly significant in all equations, but in the JV equation. The coefficient is slightly larger for WO than for LIC. In dollar terms, this means that, in the average country, a 10% improvement in the risk rating with respect to the mean generates a rise in investment due to wholly owned operations and licensing of respectively $35 and $14 million per year.

Table 7, model 3b, distinguishes between countries with strong imitative abilities and countries with weak imitative abilities. All coefficients remain basically unchanged. Our data do not seem to suggest that there exist a market expansion effect and a market power effect due to stronger IPRs. Indeed, the only significant coefficient for IPR is in the LIC equation in the case of countries with strong imitative abilities. The coefficient (significant at the 10% level) is negative suggesting that in countries with strong imitative abilities an increase in the protection of IPRs leads to a reduction in the flow of licensed technology.[13]

TABLE 7 ABOUT HERE

5.1 Extension: Modeling the decision about the technology transfer mode

The previous section has shown that higher levels of country risk reduce the flows of technology transfer in whatever mode they take place. In section 3, we have argued that firms facing higher risk might opt for technology transfer modes which entail a lower level of resource commitment: they might prefer to maintain flexibility in case things turn to worsen in the host country. So, a

[13] Using the number of researchers and engineers per million of population instead of HUMAN yields a very similar result.

higher level of risk might imply the substitution of some wholly owned operations with some more market-based alternatives, such as licensing. We have shown that such effect exists but it is no enough to overturn the reduction in investment due to higher risk, so that flows of technology licensing respond negatively to country risk as well.

Since our data allow us to trace back firms' decisions at the plant level, we can offer more evidence of the substitution effect that we have explicitly formalized in proposition 2. Indeed, we can construct a model where the probability of choosing a given mode for the transfer of the technology depends on the set of explanatory variables we discussed and used in the previous section. If the theory is correct, higher level of risk should increase (decrease) the probability of modes of technology transfer which entail lower (higher) resource commitment. In other words, higher risk ratings should increase the probability to choose a wholly owned operation and decrease the probability to select a licensing contract for the transfer of the technology.

Table 8 shows the results of three different estimations of this probabilistic formulation. Model 4a is a multinomial logit estimation, where we treat separately the three modes of technology transfer, model 4b is an ordered logit, which takes into consideration that wholly owned operations represent the highest level of integration and licensing contracts the lowest, and model 4c is a simple logit where we only consider the two polar categories: wholly owned operations and licensing.[14]

In addition to the variables used in section 5 we can now also control for firm-specific and technology-specific sources of variation. In the former case, we introduce the variable TURNOVER to control for the size of the investor. Also, notice that we have relabelled the variable DISTANCE as PROXIMITY. Indeed, this variable captures now the geographical proximity between the country where the investor has located its head quarters and the recipient country. In the latter case, we introduce a set of dummies which correspond to an aggregation of all technologies in 9 broad sectors, and the variables PATENTS and SEFS.[15] PATENTS is the

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[14] As we discussed above the way our database reports the information about joint-ventures is unclear, so we thought that dropping this category was a plausible choice. However, we have also run a logit regression in which we merged together wholly-owned operations with joint-ventures obtaining very similar results.

[15] We use the following sector dummies: Oil Refining, Petrochemicals, Minerals & Metallurgy, Plastics & Rubber, Inorganic Chemicals, Agriculture (include Fertilizers), Gas (include Gas Handling, Air Separation and Industrial

number of patents issued on a given technology by the US Patent Office in the period under study. This variable should account for the complexity of the technology, with higher values associated to more complex technologies. SEFS is the number of SEFs that have licensed that given technology in the period under study. SEFs' licensing activity tends to be concentrated in more standardized and less innovative technologies. (See section 4.2 for a brief discussion on SEFs and, for more details, Arora and Gambardella, 1998, and Arora and Fosfuri, 2000.) Hence, large values of SEFS should be associated to standard technologies which are more codified as well.

Results from all models seem to suggest that higher levels of risk reduce the probability to use a wholly owned operation to exploit a technology in a foreign country. So, firms respond to risk with technology transfer modes which entail smaller resource commitment.

Other variables seem to have the expected sign. Wholly owned operations tend to be chosen in geographical proximate countries, with higher level of education and per capita income. Licensing is more likely to be chosen for more standardized and less innovative technologies (larger values of SEFS) and simpler technologies (smaller values of PATENTS).

Stronger IPRs protection seems to have a positive impact on the probability to observe licensing, although this effect if far from being significant. All in all, this makes us a bit more confident about the result we obtained in section 4: changes in the degree of patent protection have almost no effect on the decision about which means a firm uses to exploit its technology in a foreign country.

TABLE 8 ABOUT HERE

6. Conclusions

This paper has analyzed the relationship between international technology flows and country risk. Although some empirical evidence exists on the effect of country risk on foreign direct investment, little is known about the effect of country risk on other modes of technology transfer such as joint-ventures and licensing.

Gases), Organic Chemicals (include Explosives, Textile and Fibers, Food Products and Pharmaceuticals) and Miscellaneous (the rest).

Our paper shows that the whole flow of technology transfer into a recipient economy is negative related to the level of country risk. Moreover, this effect holds for all technology transfer modes considered in our analysis, namely wholly owned operations, joint-ventures and licensing. Finally, we are also able to show that the relative effect is stronger for technology transfer modes which involve greater commitment with the recipient country, such as wholly owned operations. In sum, higher levels of country risk mean less technology transfer, that tends to be more market-based.

By contrast, we do not find evidence of a significant effect of IPRs protection on international technology transfers. Although surprising, this finding has some plausible justifications. First, our measure of patent protection reflects mainly statutory protection which might actually differ from the real protection (whether patent laws are enforced or not). Second, as reported by Cohen, Nelson and Walsh (2000) firms do not rate patents as very effective in protecting their process innovations. Finally, even if different degrees of patent protection do not affect neither the volume nor the composition of international technology flows, they might still affect the type of technology which is transferred (Fosfuri, 2000). With our data, we are not able to investigate this possibility.

At their face value, our results suggest that governments in less developed countries keen to attract foreign technology should pay greater attention to the quality of the business environment and to investment conditions rather than offering more statutory protection to IPRs. Needless to say that improving country risk ratings is neither easy nor rapid. A statutory change in patent protection or the formal participation to an international IPRs agreement are much more easy policies to implement. However, our paper shows they are not very effective.

References:

Arora, A. and Fosfuri, A. 2000. The market for technology in the chemical industry: Causes and consequences. Revue d'Économie Industrielle 92, 317-344.

Arora, A. and Fosfuri, A. 2002. Licensing the Market for Technology. Journal of Economic Behavior and Organizations, forthcoming

Arora, A. and Gambardella, A. 1998. Evolution of industry structure in the chemical industry. In Arora, A., Landau, R. and Rosenberg, N. (eds.) Chemicals and Long-Term Economic Growth. New York: John Wiley & Sons.

Arora, A., Fosfuri, A. and Gambardella, A. 2001. Markets for Technology: Economics of Innovation and Corporate Strategy. Cambridge, MA: MIT Press.

Bevan, A.A. and Estrin, S. 2000. The determinants of foreign direct investment in transition economies. CEPR Discussion Paper No. 2638. CEPR, London.

Brainard, L.S. 1997. An empirical assessment of the proximity-concentration trade-off between multinational sales and trade. American Economic Review 87, 520-544.

Cohen, W.M. and Levinthal, D. 1989. Innovation and learning: The two faces of R&D. Economic Journal 99, 569-596.

Cohen, W.M., Nelson, R.R. and Walsh, J. 2000. Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not). NBER Working Paper No. 7552. NBER, Cambridge, MA.

Dunning, J.H. 1981. International Production and the Multinational Enterprise. George Allen and Unwin, London.

Erb, C.B., Harvey, C.R. and Viskanta, T.E. 1996. Political Risk, Economic Risk and Financial Risk. Financial Analysts Journal. November/December.

Ethier, W.J. 1986. The multinational firm. Quarterly Journal of Economics 101(3), 805-833.

Ethier, W.J. and Markusen, J.R. 1996. Multinational firms, technology diffusion and trade. Journal of International Economics 41, 1-28.

Ferrantino, M.J. 1993. The effects of intellectual property rights on international trade and investment. Weltwirtschaftliches Archiv 129, 300-331.

Fink, C. 1997. Intellectual Property Rights and U.S. and German International Transactions in Manufacturing Industries. Mimeo.

Flamm, K. 1984. The volatility of offshore investment. Journal of Development Economics 16, 231-248.

Fosfuri, A. 2000. Patent protection, imitation and the mode of technology transfer. International Journal of Industrial Organization 18, 1129-1149.

Fosfuri, A., Motta, M. And Roende, T. 2001. Foreign direct investment and spillovers through workers' mobility. Journal of International Economics 53, 205-222.

Ginarte, J.C. and Park, W.G. 1997. Determinants of patents rights: a cross-national study. Research Policy 26, 283-301.

Holland, D. and Pain, N. 1998. The Diffusion of Innovations in Central and Eastern Europe: A Study of the Determinants and Impact of Foreign Direct Investment. NIESR Discussion Paper No. 137. National Institute of Social and Economic Research, London.

Jun, K.W. and Singh, H. 1996. The Determinants of Foreign Direct Investment: New Empirical Evidence. Transnational Corporations 5, 67-106.

Kogut, B. and Zander, U. 1993. Knowledge of the firm and evolutionary theory of the multinational corporation. Journal of International Business Studies 24, 625-645.

Lee, J.Y. and Mansfield, E. 1996. Intellectual Property Protection and U.S. Foreign Direct Investment. The Review of Economics and Statistics 78(2), 181-186.

Lucas, R. 1993. On the Determinants of Direct Foreign Investment: Evidence from East and Southeast Asia. World Development 21(3), 391-406.
Markusen, J.R. 1995. The boundaries of multinational enterprises and the theory of international trade. Journal of Economic Perspectives 9, 169-190.
Maskus, K.E. 1998. The international regulation of intellectual property. Weltwirtschaftliches Archiv 134, 186-208.
Maskus, K.E. and Penuberti, M. 1995. How trade-related are intellectual property rights? Journal of International Economics 39, 227-248.
Motta, M. 1992. Multinational firms and the tariff-jumping argument. European Economic Review 36, 1557-1571.
Primo Braga, C.A. and Fink, C. 1998. International Transactions in Intellectual Property and Developing Countries. International Journal of Technology Management.
Rapp, R.T. and Rozek, R.P. 1990. Benefits and costs of intellectual property protection in developing countries. Journal of World Trade 24, 75-102.
Smith, P.J. 1999. Are weak patent rights a barrier to U.S. exports? Journal of International Economics 48, 151-177.
Smith, P.J. 2001. How do foreign patent rights affect U.S. exports, affiliate sales, and licenses? Journal of International Economics 55, 411-439.
Wheeler, D. and Mody, A. 1992. International investment location decisions. Journal of International Economics 33, 57-76.
Williamson, O. 1991. Comparative economic organization – The analysis of discrete structural alternatives. Administrative Science Quarterly 26(4), 269-296.
Wright. D.J. 1993. International technology transfer with an information asymmetry and endogenous research and development. Journal of International Economics 35, 47-67.

Appendix

List of countries used in the empirical estimations: Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Cameroon, Canada, Chile, Colombia, Congo, Costa Rica, Cyprus, Denmark, Ecuador, Egypt, El Salvador, Finland, France, Germany (West), Greece, Guatemala, Honduras, Hong Kong, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Korea, Malawi, Malaysia, Mauritius, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Thailand, Trinidad and Tobago, U.S.A., Uganda, Uruguay, Venezuela, Zambia, Zimbabwe.

<u>FIGURES AND TABLES</u>

Figure 1: *Predicted parameter signs*

Variable	**Abbreviation**	**Wholly Owned**	**Joint-Venture**	**Licensing**
Population	POP	Positive	Positive	Positive
Income Per Capita	PCGDP	Positive	Positive	Positive
Distance	DIST	Ambiguous	Ambiguous	Ambiguous
Openness to Trade	OPEN	Ambiguous	Ambiguous	Ambiguous
Country Risk	R	Positive	Ambiguous	Ambiguous
IPRs Protection	IPR	Ambiguous	Ambiguous	Ambiguous
Level of Education	HUMAN	Ambiguous	Ambiguous	Ambiguous

Table 1: *Top 20 firms involved in international technology transfers (by number of plants) in the chemical industry during the 1981-1991.*

Company	**Nationality**	**Total**	**WO (rank)**	**JV (rank)**	**LIC (rank)**
Shell	Anglo-Dutch	492	264 (1)	119 (1)	109 (4)
ICI	British	243	117 (5)	13 (15)	113 (2)
Exxon	American	223	164 (2)	26 (8)	33 (19)
Hoechst	German	214	131 (4)	36 (3)	47 (11)
Air Liquide	French	212	92 (8)	4 (30)	116 (1)
BASF	German	196	138 (3)	12 (16)	46 (13)
Du Pont	American	170	101 (7)	22 (10)	47 (11)
Dow Chemical	American	167	109 (6)	36 (3)	22 (25)
BP	British	150	79 (9)	27 (6)	44 (14)
Union Carbide	American	143	26 (28)	4 (30)	113 (2)
Monsanto	American	140	34 (22)	11 (18)	95 (5)
Rhone-Poulenc	French	130	60 (11)	18 (12)	52 (7)
Texaco	American	104	54 (12)	1 (52)	48 (10)
Mobil	American	100	50 (15)	28 (5)	22 (25)
Air Products	American	90	29 (26)	1 (52)	60 (6)
Amoco	American	88	22 (36)	17 (13)	49 (9)
Montedison	Italian	80	21 (39)	24 (9)	35 (16)
BOC	British	79	51 (14)	21 (11)	7 (43)
Bayer	German	77	62 (10)	3 (37)	12 (34)
Phillips	American	75	20 (40)	4 (30)	51 (8)

Table 2: *Distribution of technology flows (number and value) by geographic areas during the period1981-1991 in the chemical industry (by the firms of our sample)*

		AF	EE	FE	JAP	ME	NA	SA	WE	Total
WO	*Number*	72	10	426	86	21	883	273	1065	2836
	Value	7.7	0.7	40.9	3.7	2.8	63.6	27.8	56.5	203.7
	Share	34	4	36	33	8	83	56	73	54
JV	*Number*	17	51	256	65	83	39	55	96	662
	Value	1.8	3.5	24.6	2.8	10.8	2.8	5.7	5.1	57.1
	Share	8	20	21	25	33	4	11	6	13
LIC	*Number*	123	196	513	107	151	145	161	302	1698
	Value	13.2	13.3	49.2	4.6	19.8	10.4	16.4	10.0	136.9
	Share	58	76	43	42	59	13	33	21	33
Total	*Number*	212	257	1195	258	255	1067	489	1463	5196
	Value	22.7	17.5	114.7	11.1	33.4	76.8	49.9	77.6	403.7

Note: Value in billions of US dollars.

Table 3: *International technology transfers (number) by selected sectors in the chemical industry during the period 1981-1991 (by the firms of our sample)*

	AS	IG	OC	OR	PC	PH	PL	SF+TF
WO	155 (52)	103 (41)	248 (74)	358 (56)	427 (40)	274 (91)	464 (47)	108 (51)
JV	22(8)	15 (7)	34 (10)	79 (12)	197 (16)	9 (3)	148 (16)	23 (11)
LIC	118 (40)	115 (52)	53 (16)	210 (32)	448 (44)	18 (6)	367 (37)	79 (38)
Total	295	223	335	647	1072	301	979	210

Note: AS = Air Separation, IG = Industrial Gases, OC = Organic Chemicals, OR = Oil Refining, PC = Petrochemicals, PH = Pharmaceuticals, PL = Plastics, SF+TF = Synthetic Fibers.

Table 4: *Variables and sources*

Variable	**Description**	**Source**
ALL_{it}	Investment in country i and period t generated by any of three modes of technology transfer (measured in millions of US dollars)	Chemintell (1991)
WO_{it}	Investment in country i and period t generated by technology transfer through wholly owned operations (measured in millions of US dollars)	Chemintell (1991)
JV_{it}	Investment in country i and period t generated by technology transfer through joint-ventures (measured in millions of US dollars)	Chemintell (1991)
LIC_{it}	Investment in country i and period t generated by technology transfer through licensing (measured in millions of US dollars)	Chemintell (1991)
POP_{it}	Population in country i at the beginning of period t (in thousands)	Penn World Table
$PCGDP_{it}$	(Real) per capita income in country i at the beginning of period t (in dollars)	Penn World Table
$DIST_{i}$	Weighted distance of country i's capital to capitals of 20 major exporters (in kilometers)	Barro and Lee (1994)
$HUMAN_{it}$	Averaged schooling years in the total population over age 25 in country i at the beginning of period t	Barro and Lee (1994)
$OPEN_{it}$	(Exports + Imports)/GDP at current international prices in country i at the beginning of period t	Penn World Table
IPR_{it}	Strength of patent protection in country i at period t. This is an index which accounts for the extent of patent coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms and duration of protection	Park and Ginarte (1997)
R_{it}	Global index of risk in country i at the beginning of period t	Institutional Investor Credit Rating
DUM1	Dummy variables equal to 1 for the period 1984-1987 and 0 otherwise	Chemintell (1991)
DUM2	Dummy variable equal to 1 if for the period 1988-1991 and 0 otherwise	Chemintell (1991)

Table 5: *Descriptive statistics (n = 213)*

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
ALL_{it}	1458,5	2813,4	0	16402
WO_{it}	901,0	2150,2	0	13924
JV_{it}	160,2	385,8	0	2772
LIC_{it}	397,3	663,1	0	3740
POP_{it}	37394	97180	228	849515
$PCGDP_{it}$	5804	5185	264	21827
$DIST_{i}$	5861	2440	1267	11500
$HUMAN_{it}$	5,1	2,8	0,5	12,1
$OPEN_{it}$	66,5	50,5	10,5	423,4
IPR_{it}	2,58	0,94	0	4,52
R_{it}	46,1	27,4	4,4	98,6
DUM1	0,33	0,47	0	1
DUM2	0,33	0,47	0	1

Table 6: *OLS and Tobit estimations: ALL_{it}*

	OLS: ALL_{it}		TOBIT: ALL_{it}	
	Model 1	**Model 2**	**Model 1a**	**Model 2a**
Constant	-23.329*** (6.030)	-27.459*** (6.492)	-32.007*** (8.222)	-35.525*** (8.869)
POP_{it}	1.194*** (0.125)	1.180*** (0.125)	1.394*** (0.179)	1.382*** (0.178)
$PCGDP_{it}$	1.221*** (0.350)	1.253*** (0.349)	1.262** (0.504)	1.281** (0.501)
$DIST_{i}$	0.342 (0.344)	0.337 (0.343)	0.541 (0.469)	0.524 (0.467)
$HUMAN_{it}$	-0.632 (0.414)	-0.162 (0.499)	-0.966 (0.587)	-0.521 (0.722)
$OPEN_{it}$	0.006* (0.003)	0.005 (0.003)	0.007 (0.005)	0.006 (0.005)
IPR_{it}	-0.091 (0.521)		-0.032 (0.759)	
$DWEAK*IPR_{it}$		-0.456 (0.563)		-0.338 (0.812)
$DSTRONG*IPR_{it}$		0.242 (0.556)		0.282 (0.814)
R_{it}	1.778*** (0.366)	1.862*** (0.367)	3.203*** (0.601)	3.243*** (0.597)
DUM1	-0.127 (0.382)	-0.131 (0.380)	0.011 (0.540)	0.000 (0.537)
DUM2	-0.234 (0.413)	-0.233 (0.411)	0.015 (0.598)	0.006 (0.594)
Number of obs.	213	213	213	
Left-censored			70	70
Adjusted R2	0.639	0.642		
Pseudo R2			0.210	0.211

Note: Standard Errors are shown in parenthesis. *10%, **5%, ***1%.

Table 7: *SUR estimations*

Model 3a			
	WO_{ij}	**JV_{ij}**	**LIC_{ij}**
Constant	-27.947***	-34.921***	-25.138***
POP_{it}	1.221***	0.893***	1.099***
$PCGDP_{it}$	0.691**	1.035***	1.367***
$DIST_{i}$	0.210	0.180***	0.656*
$HUMAN_{it}$	0.731*	0.008	-0.878**
$OPEN_{it}$	0.008**	0.000	-0.000
IPR_{it}	-0.271	-0.442	-0.565
R_{it}	1.407***	0.547	1.327***
DUM1	-0.209	-0.069	0.120
DUM2	-0.243	0.315	-0.051
Number of obs.	213	213	213
R-sq	0.640	0.431	0.570
Model 3b			
	WO_{ij}	**JV_{ij}**	**LIC_{ij}**
Constant	-31.669***	-35.856***	-30.380***
POP_{it}	1.209***	0.891***	1.081***
$PCGDP_{it}$	0.720**	1.042***	1.408***
$DIST_{i}$	0.206	1.179***	0.651*
$HUMAN_{it}$	1.154**	0.114	-0.282
$OPEN_{it}$	0.007**	0.000	-0.001
$DWEAK*IPR_{it}$	-0.600	-0.524	-1.028*
$DSTRONG*IPR_{it}$	0.029	-0.366	-0.142
R_{it}	1.482***	0.566	1.433***
DUM1	-0.213	-0.070	0.114
DUM2	-0.242	0.316	-0.050
Number of obs.	213	213	213
R-sq	0.644	0.431	0.579

Note: *10%, **5%, ***1%.

Table 8: *Multinomial logit, ordered logit and logit estimations*

	Multinomial logit (baseline = WO)		Ordered logit	Logit
	JV	**LIC**	**1 = WO, 2 = JV, 3 = LIC**	**1 = WO, 0 = LIC**
Constant	1.118**	1.274***	-1.410*** -0.909***	-1.116***
POP	0.000	0.000**	0.000	-0.000***
PCGDP	-0.000	-0.000***	-0.000***	0.000***
PROXIMITY	-1.781***	-0.545***	-0.663***	0.523***
HUMAN	-0.000	-0.000***	-0.000***	0.000***
OPEN	-0.002	-0.004***	-0.003***	0.004***
IPR	-0.280***	0.082	0.099	-0.066
R	-0.010*	-0.009***	-0.008**	0.009**
TURNOVER	-0.000	-0.000***	-0.000***	0.000***
PATENTS	-0.003**	-0.003***	-0.003***	0.003***
SEFS	0.043**	0.028**	0.028***	-0.026**
Number of obs.	2528		2528	2263
Pseudo R2	0.122		0.091	0.128

Note: *10%, **5%, ***1%.